INTERPRETIVE SUMMARY

Pregnancy diagnosis in predicting days open. *By Wiggans and Goodling, page* 0000. The system for predicting days open for cows with between 130 and 249 DIM without a subsequent calving was revised to have different equations for cows confirmed to be pregnant, confirmed to be open, or with unknown pregnancy status. The largest difference was for lactations of cows confirmed to be open where the original system underpredicted days open by >96 d for the 130-to-149 DIM interval. This method to improve predictions of days open was applied for daughter pregnancy rate evaluations beginning in November 2004.

PREGNANCY DIAGNOSIS IN PREDICTING DAYS OPEN

Accounting for Pregnancy Diagnosis in Predicting Days Open

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ABSTRACT

The system for estimating days open for cows with no subsequent lactation was examined to determine if estimates should vary depending on pregnancy diagnosis. Pregnancy diagnosis information was unavailable when the original prediction system was developed, but was begun in 2002. New prediction equations were estimated from nearly 1.1 million Holstein lactations for 20-d intervals from 110 to 250 DIM. Use of pregnancy diagnosis improved accuracy compared to the original system. The improvement was particularly evident for lactations of cows confirmed to be open in the 130-to-149 DIM interval, where predicted days open increased by >96 d. For lactations of cows with a confirmed pregnancy, predicted days open decreased by 18 d for the same interval. Prediction errors decreased with increasing DIM. Jersey lactations averaged fewer days open, but in most cases Holstein solutions provided adequate predictions. Specific adjustments were generated for Jersey lactations with no breedings reported. Those adjustments reduced the predicted days open averaged across parity by an amount that increased from 9 to 27 d with DIM interval. The new prediction equations were implemented for November 2004 evaluations for daughter pregnancy rate.

(**Keywords:** pregnancy confirmation, days open)

Abbreviation Key: DPR = daughter pregnancy rate, **DO** = days open, **PD** = pregnancy diagnosis

INTRODUCTION

In February 2003, the Animal Improvement Programs Laboratory implemented an evaluation for female fertility called daughter pregnancy rate (**DPR**) (VanRaden et al., 2004). The evaluation is based on days open (**DO**) and includes a system for estimating DO developed by Kuhn et al. (2004), which allows inclusion of records before DO can be confirmed by a subsequent calving. Data available for developing that system did not include pregnancy diagnosis (**PD**) because collection of that information did not start until 2002. With over 2 yr of data now available, predictions could be developed specifically for cows confirmed to be pregnant or to be open.

Pregnancy diagnosis is a common management practice. Fricke (2002) reports that ultrasound imaging can provide accurate information as early as 30 d after insemination. Historically, rectal palpation has been used at ≥45 d.

For cows confirmed to be pregnant, actual DO may be greater than DO at last breeding because the cow became pregnant from a later unreported breeding, the PD was wrong, or the cow aborted after PD. Cows confirmed to be open are expected to have longer DO than cows with the same DIM at last breeding and no confirmation because many unconfirmed cows may be pregnant, but few of the cows confirmed to be open are expected to be pregnant. A cow bred after having been confirmed to be open would revert to unknown pregnancy status. The purpose of this study was to determine if information on PD improves prediction of DO and if so, modify the prediction of DO to use PD.

MATERIALS AND METHODS

Data

Breeding records either supplied as part of the lactation record or as part of a recent implementation of collection of reproduction information were extracted for parities 1 through 5 for calvings from October 2001 through March 2003. The upper limit on date was chosen to allow for a subsequent calving to verify DO. Lactations designated as “do not breed” were excluded because such cows do not provide useful information for prediction of DO, particularly if the designation is early in lactation. Because of national reporting of pregnancy confirmation, collection could be restricted to herds with a high level of reporting. To be included, herds were required to have a test on or after October 1, 2001, ≥365 d between the first and last test and to have at least seven tests during the 365 d following the first test. To eliminate small herds, records from a herd were used starting with the first test date for which a herd had ≥50 cows in milk.

The DPR evaluation imposes a ceiling of 250 d on DO to limit the effect of the skewness of the distribution (VanRaden et al., 2004). For a lactation to be used in this study, there must have been either a subsequent lactation to verify DO or evidence that DO was ≥250. Such evidence included being culled for reproductive reasons or a breeding or confirmed-open diagnosis at ≥250 DIM. Estimated breeding date was calculated as subsequent calving date minus gestation interval (290 d for Brown Swiss and 280 d for other breeds). Breedings where the date was >18 d after estimated breeding date were excluded to eliminate breedings to pregnant cows.

Herds were eliminated if less than 50% of cows had a PD reported. Requiring herds to have a high level of reporting of PD ensured exclusion of herds for which only problem breeders were checked. Herds with <10% or >75% of breedings that resulted in conception were excluded to eliminate herds with selective reporting. Seventy-five percent of the cows in a herd were required to have a breeding reported. Records for 1,095,629 Holstein and Red-and-White and 76,802 Jersey lactations were included in the analysis after imposing the edits.

Model

The model of Kuhn et al. (2004) was used:

$$y = \text{intercept} + \text{parity} + \text{CE} + \beta_1\text{age} + \beta_2\text{age}^2 + \beta_3\text{DO}_\text{L} + \text{e},$$

where y = DO (breeding date – calving date), CE = calving ease score (1 through 5), age = calving age in years (e.g., 2.5 yr), DO_L = DO at last breeding before the end of the interval (may be a breeding in a prior interval, the term was dropped from model if the cow had not been breed yet), β = regression coefficient for effect, and e = residual. That model, in full or part, was applied to 56 data sets, which were defined by seven 20-DIM intervals starting at 110 DIM, the presence or absence of calving ease information, and 4 classes for breeding and PD information (no breeding, pregnancy status unknown, confirmed to be pregnant, and confirmed to be open). A particular breeding with a diagnosis contributed to the unknown status group until 45 d after breeding when the diagnosis was assumed to have occurred. The end of the DIM interval was used for this determination. The actual date of diagnosis was missing for a majority of data.

Cows with subsequent heats reported were included in the group diagnosed to be open for that breeding. When more than one pregnancy diagnosis or indication followed a breeding, the last one was used. In addition to analysis of Holstein data, applicability of Holstein results to Jersey data was investigated. Holstein results were assumed to apply to other breeds because mean DO values were similar to Holstein values.

To determine the characteristics of pregnancy diagnosis reporting, a separate study of data supplied by AgSource was conducted. AgSource was the only center that reported the date of diagnosis. For cows calving between December 2003 and December 2004 with diagnosis between May and December 2004, the average days between breeding and a diagnosis of pregnant was 45d and where a diagnosis of not pregnant occurred, 40d. Of the 122,974 diagnoses, 39 percent were not pregnant and 61 percent were pregnant. Data from Dairy Records Management Systems had only 15 percent not pregnant of 140,865 diagnoses from the same period. This lower value probably results from only the last diagnosis in a test interval being reported with an approximate date. The other processing centers did not report the date of diagnosis.

Genetic Correlations

Genetic correlations were estimated among predictions for 7 DIM intervals and actual DO using REML and a sire model as in Kuhn et al. (2004). The model was

$$y = hysp + s + e$$

where y = vector of 7 predicted DO and actual DO; hysp = herd-year-season-parity effect, with seasons starting in January, March, June, September, and November; s = sire effect; and e = residual. Relationships through sire and maternal grandsire were considered.

Comparison with Original Prediction

Original prediction equations (Kuhn et al., 2004) were applied to data used for estimating regressions. Prediction errors and standard deviations were calculated. The same values also were calculated for the new prediction equations. Because the same data were used for the estimation, the prediction errors for the new prediction equations were expected to average 0.

RESULTS AND DISCUSSION

Regressions

Eight sets of regression equations were estimated for each of the seven DIM intervals. Results are reported for only the second and last intervals. Results for intervals not displayed followed the trend established by this range. The first interval was not displayed because results from that interval were not implemented. Mean prediction errors and standard deviations are in Table 1 and solutions are in Tables 2 and 3. The percentage of lactations without a breeding decreased from 5.6 to 1.1 over the 100 d between reported periods and percentage of lactations with PD, both pregnant and open, increased from 38.1 to 70.4 percent. The percentage of PD that were not pregnant was lower than found in recent data. This may reflect that as DIM increases, a cow is rebred and then may be diagnosed pregnant. A cow may also be diagnosed not pregnant because the diagnosis was too early to detect the pregnancy. In this study, the last diagnosis in an interval was used. All 1,095,629 Holstein and Red-and-White lactations contributed to each interval, because each interval used all data available during and before that interval.

Mean prediction errors in Table 1 resulted from applying the equations of Kuhn et al. (2004). Largest mean errors were for the confirmed-open groups in the 130-to-149 DIM interval. The correlations also show the value of a successful last breeding in predicting days open. Underprediction of DO was >96 d. As expected, confirmed-pregnant groups had predicted DO that were too high by about 18 d. Records for cows with unknown pregnancy status (those records that remained after removing records of cows confirmed to be pregnant and the relatively few cows confirmed to be open) had a corresponding underprediction. Those mean prediction errors tended to be smaller in the last DIM group. As expected, mean prediction errors were small for lactations without breedings in the early interval, which indicated that the new predictions were similar to those of Kuhn et al. (2004). Mean prediction errors for lactations of cows with unreported breedings were greater in the last interval, but the counts were much smaller.

The standard deviations of prediction errors were generally smaller for the new predictions, but that could be because the same data were used to estimate the predictions as were used for the comparison. As with the mean prediction errors, the greatest benefit was for cows confirmed to be open. Even for the 230-to-249 DIM group, DO of the last breeding was not final DO for 3.5% of the lactations, which explains why the standard deviation of prediction errors was not zero. Fifteen percent of cows confirmed to be open were actually pregnant from their last breeding, and 52% of the lactations of cows in the unknown pregnancy status groups had final DO different from DO reported at last breeding.

The solutions in Table 2 show that the values are similar for equations with and without calving ease data. The regression coefficients on DO for the confirmed pregnant and unknown pregnancy status equations are >0.9 indicating that DO at last breeding comprises most of the estimate. For the confirmed open equations, the coefficients are around 0.5 indicating that failed breedings provide some information on the eventual DO. Table 3 gives the solutions for calving ease generally showing that predicted DO increases with calving ease score, particularly at early DIM when there is no PD. However, at late DIM, predicted DO changes little with changes in calving ease score when PD is not known. This indicates an interaction between CE scores and the two information categories for no PD and pregnant. The predicted DO for calving ease score 5, parity 5, and breeding at 110 DIM also is given to permit comparison with results in Table 4.

To illustrate effect of PD information on predictions, Table 4 shows predictions for 110 DIM at last breeding and two ages for the four information categories for breeding and pregnancy confirmation. Without a breeding, predicted DO was >200 d. With a breeding, predicted DO decreased towards the last breeding date at 110-DIM with increasing DIM. For cows confirmed to be pregnant, predicted DO was never >115.5 d. The benefit of the pregnancy confirmation compared with an unknown pregnancy status declined with increasing DIM from >40 d to 15 d. Predicted DO for cows confirmed open also declined with increasing DIM. That decline appeared to reflect the abnormal situation presented in the example where an open cow is not rebred and not designated as "do not breed.” The comparison of parities 1 and 5 showed slightly higher predictions for the later lactation, particularly when no breeding was reported or the breeding was confirmed to be unsuccessful.

Application to Jersey Data

Solutions estimated from Holstein data were applied to Jersey data and were found to have similar accuracy and prediction error except for records without breedings. For that group, adjustments by parity (1 to 5) and DIM interval (6 intervals starting at 130 DIM) were calculated (Table 5). When averaged across parity, mean prediction error increased from 9 to 27 d with the DIM intervals. The values in Table 5 are applied to reduce predicted DO.

Genetic Correlations

Correlations and heritabilities are in Table 6 for the seven DIM intervals and final DO. The results are nearly the same as those of Kuhn et al. (2004). The heritabilities are slightly lower, which possibly reflects the shorter period included in the data.

CONCLUSIONS

Information from PD improves the accuracy of prediction of DO. The largest improvement was for cows diagnosed to be open where DO was previously under predicted by over 96 d for the 130 to 149 DIM interval. A smaller improvement was observed for the much larger number of cows confirmed to be pregnant. The 3.5% of cows where the confirmed last breeding was not the final DO demonstrates the value of applying a prediction process instead of equating a pregnancy confirmation to having a subsequent calving. Although coefficients for prediction equations were estimated for the 110 to 129 DIM interval, there was not a sufficient improvement in accuracy to lower the threshold for predicting DO to include them, so the 130-d requirement established by Kuhn et al. (2004) was retained. The prediction system developed in this study was implemented for the November 2004 DPR evaluation. Expansion factors adjust the variance of incomplete records to meet the expectations of the model which assumes that such records have the same genetic variance but more error variance than completed records. The incorporation of PD into the prediction system increased the variance of the DO in early lactation so the expansion factors in the evaluation system were reduced proportionally. Records are weighted to reflect their accuracy. Although, as shown in Table 1, accuracy in predicting days open differs by PD and presence of a breeding, these factors were not considered in the weights because they are correlated with the value of DO. At a given DIM, open cows have higher DO than confirmed pregnant cows. Weights were based only on DIM for simplicity and to avoid bias.

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Table 1. Number of lactations by category of information, mean prediction errors (predicted – actual) of previous prediction equation, and SD of prediction error for two DIM intervals.

	Information					SD of Prediction Error		
DIM	Breeding	Diagnosis	Calving Ease	Lactations (no.)	Mean Prediction Error	New	Previous	Correlation
130-149	No	No	No	46,037	4.2	43.0	43.3	0.12
	No	No	Yes	15,411	1.8	39.6	40.0	0.15
	Yes	No	No	393,659	-17.2	55.9	56.5	0.39
	Yes	No	Yes	223,218	-17.1	55.0	55.5	0.41
	Yes	Pregnant	No	235,574	18.4	27.7	28.0	0.50
	Yes	Pregnant	Yes	151,211	17.2	26.2	26.6	0.51
	Yes	Open	No	19,405	-96.4	59.5	60.6	0.15
	Yes	Open	Yes	11,114	-99.7	55.8	57.4	0.14
230-249	No	No	No	9,201	32.8	63.3	64.6	0.20
	No	No	Yes	2,812	16.3	48.1	49.1	0.20
	Yes	No	No	204,878	-9.3	32.3	32.6	0.90
	Yes	No	Yes	107,624	-7.8	29.0	29.3	0.92
	Yes	Pregnant	No	455,757	3.9	18.2	18.3	0.92
	Yes	Pregnant	Yes	277,433	4.0	16.3	16.4	0.93
	Yes	Open	No	24,839	-79.2	54.6	59.1	0.41
	Yes	Open	Yes	13,085	-80.3	52.1	57.7	0.41

Table 2. Coefficients for prediction of days open for two DIM intervals and the eight combinations of information.

	Information			Parity							Days Open[1]
DIM	Breeding	Diagnosis	Calving Ease	1	2	3	4	5	Age	Age^2	
130-149	No	No	No	195.7	189.7	183.2	176.9	167.8	5.28	0.36	
	No	No	Yes	196.4	189.0	183.4	179.7	173.5	11.41	-0.39	
	Yes	No	No	32.5	17.1	-1.4	-21.2	-42.2	10.49	0.91	0.90
	Yes	No	Yes	40.6	28.5	10.0	-9.4	-30.8	7.25	1.21	0.96
	Yes	Pregnant	No	3.8	2.2	-0.6	-4.1	-8.0	0.45	0.31	0.98
	Yes	Pregnant	Yes	5.6	5.3	3.4	0.6	-2.7	-0.71	0.35	0.99
	Yes	Open	No	151.6	144.3	135.2	123.8	113.0	2.18	0.92	0.49
	Yes	Open	Yes	171.2	167.8	162.3	154.9	145.1	0.38	0.83	0.42
230-249	No	No	No	166.1	160.1	155.1	149.8	137.9	18.27	-0.63	
	No	No	Yes	200.7	202.0	195.5	198.0	194.8	15.88	-0.99	
	Yes	No	No	3.5	-5.8	-14.3	-23.0	-30.7	8.16	0.02	0.97
	Yes	No	Yes	1.0	-7.0	-15.5	-23.4	-32.0	8.36	-0.06	0.99
	Yes	Pregnant	No	1.0	-0.3	-1.6	-3.3	-4.9	0.69	0.10	1.00
	Yes	Pregnant	Yes	2.5	2.0	1.0	-0.1	-1.9	-0.22	0.16	1.00
	Yes	Open	No	142.8	142.3	137.8	132.0	127.1	-0.56	0.70	0.54
	Yes	Open	Yes	154.0	152.2	151.1	148.8	147.0	3.45	0.03	0.50

[1] days open at last breeding.

Table 3. Adjustments to prediction of days open for calving ease score differences from 5 by calving ease score for two DIM intervals and four combinations of information and predicted days open for calving ease score 5 with last breeding at 100 DIM in parity 5 at 6.3 years of age.

	Information		Calving Ease Score				
DIM	Breeding	Diagnosis	1	2	3	4	Predicted Days Open
130-149	No	No	-10.2	-7.9	-6.2	-0.4	230.2
	Yes	No	-10.7	-8.1	-8.1	-2.8	169.2
	Yes	Pregnant	-1.1	-0.7	-1.2	-0.8	116.2
	Yes	Open	-9.6	-7.4	-3.0	-0.6	227.0
230-249	No	No	-14.4	-7.8	-9.6	3.3	255.8
	Yes	No	-2.8	-1.9	-2.4	-1.0	128.1
	Yes	Pregnant	-0.9	-0.7	-0.8	-0.5	113.1
	Yes	Open	-11.0	-8.6	-1.9	-2.2	224.7

Table 4. Predicted days open without calving ease scores for last breeding at 110 DIM for parities 1 and 5 with and without breeding and confirmation data by DIM.

			Days open			
Parity	Age (yr)	DIM	No breeding	No confirmation	Confirmed pregnant	Confirmed open
1	2.0	140	207.7	156.2	114.1	213.6
		160	215.5	151.9	114.0	215.5
		180	219.2	145.7	113.8	215.1
		200	218.4	138.9	113.5	212.6
		220	212.8	132.7	113.0	208.6
		240	200.1	127.1	112.7	203.7
5	6.3	140	215.7	159.9	115.5	217.9
		160	223.0	154.9	115.5	220.2
		180	227.8	148.2	114.9	220.4
		200	230.1	141.1	114.5	218.0
		220	230.1	134.5	113.9	215.0
		240	228.5	129.2	113.2	210.8

Table 5. Reduction in predicted days open for Jersey cows without a breeding by parity for two DIM intervals.

	Parity				
DIM	1	2	3	4	5
130-149	8	11	10	9	8
230-249	25	34	32	27	17

Table 6. Correlations of predicted days open with days open from completed lactations and heritability by DIM.

DIM (20-d interval)	Correlations		
	Phenotypic	Genotypic	Heritability[1]
110	0.615	0.964	0.0326
130	0.709	0.979	0.0318
150	0.778	0.986	0.0333
170	0.828	0.990	0.0337
190	0.866	0.995	0.0343
210	0.895	0.997	0.0342
230	0.918	0.997	0.0346
Completed	1.000	1.000	0.0364

[1]Standard errors are approximately 0.0029.